AEI

Electrical Distribution

THE NEWS MAGAZINE OF THE CABLE AND CONSTRUCTION (CABLES & LINES) DIVISIONS OF ASSOCIATED ELECTRICAL INDUSTRIES LTD

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EDITORIAL

CONGRATULATIONS ARE DUE to the Electrical Contractors' Association, which celebrates its diamond jubilee this year. Its work during the past sixty years has been marked by the establishment of a reputation for good-class work by E.C.A. members and progressively improved conditions for workers in the electrical contracting industry. Mr C. R. Waterhouse, the Association's president, speaking at Bradford recently, spoke of encouraging the right kind of boy to choose a career in electrical engineering. Today, he said, more attention was being paid to training methods through apprenticeship schemes.

The president's remarks emphasize the policy of the Government White Paper, *Better Opportunities in Technical Education*. It is well known that industry's contribution to further education is very large, not only in terms of grants to colleges and the employment of specialized staff but also in "time off" for attendance at classes and lectures. Implementation of the White Paper will increase that contribution still further. It is a very necessary contribution: today, when Britain must sell in order to produce, technical advance is at more of a premium than ever it was in the past.

AEI

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OUR COVER PICTURE

275kV terminations at Tilbury, part of a supergrid job in the West Thurrock area, form the subject for this month's cover. The contract is described on pages 68–9.

News in brief...

A.E.I.'s Large Signalling Contract

THE BRITISH TRANSPORT Commission, on behalf of British Railways, Southern Region, have awarded a large railway signalling contract to A.E.I.–GRS Limited.

The work, on the Sevington–Dover section, is all part of the progress being made in the electrification of the Kent coast lines.

The A.E.I. Construction (Cables and Lines) Division is to carry out, for A.E.I.–GRS Limited, the signalling cable section of the contract. A total of 157 000yd of A.E.I. power, control, and telephone cables is to be installed, over a route length of twenty miles of track. The cables will be laid in surface concrete troughing for most of the route, but where they pass through stations the cables will be installed in troughing 18in. below the platform surface.

Forty Years with Cables

THREE A.E.I. CABLE DIVISION men received gold watch awards from the Company recently to mark forty years' service.

Mr W. H. Copper, London regional cable sales manager, was one. He joined Henley's Bought Ledger Department way back in 1920. In 1945 he was made Henley's London Branch manager and, more recently, on the integration of Henley's into the Woolwich Group of A.E.I., he was appointed to his present position.

Well-known personality at Exeter Branch, Mr W. A. Dobson has also received a gold watch tribute to mark his long service. His early years were spent with Henley's Export Sales Department, until, in 1931, he became a representative for Bristol Branch. He followed this by shortly afterwards being appointed manager of Henley's Exeter Branch.

Third member of the Division with a new gold watch is Mr B. S. Cooper, representative at Southampton since 1934. Previous to this he had spent fourteen years at Henley's Head Office in various departments. He served in H.M. Forces from 1941 to 1945 after which he returned to representative duties at Southampton.

▼ Divisional general manager, Mr E. J. Vidler (*left*), presents Mr Copper with his gold watch while Mr H. D. Parsons, divisional sales manager, looks on.

A.S.E.E. Exhibition Tenth Year at Earl's Court

THE TENTH Electrical Engineers' Exhibition is to be held at Earl's Court from 21 to 25 March. It will cover nearly half a million square feet of exhibition space.

At the show more than 460 of the electrical industry's manufacturers will display and demonstrate their products—which include motor control gear, cables, insulation materials, transformers, circuit-breakers, and domestic and industrial equipment over the whole range of the industry.

On the second day of the exhibition, at 6.30 p.m., a lecture on electrical installations for large industrial projects will be given in the Cromwell Hall, by Sir Henry Clay, Bt, M.A.(CANTAB.), M.I.E.E., of McLellan and Partners, Consulting Engineers.

The special feature of this year's exhibition has the theme of "Communications", showing the latest developments in telephone communications and railway electrification and control. The British G.P.O. will show various aspects of their current electrical work within the feature, including the new equipment devised for direct long-distance dialling and automatic connection. New developments in techniques on London's Underground electrical railway system, such as automatic programming and newly devised equipment which reveals the behaviour of the electrical system while the trains are running, will also be on show. The organizers of the exhibition are planning the "Communications" feature in co-operation with the G.P.O., the British Transport Commission, and British electrical manufacturers to place emphasis on the research which is constantly going on in this field.

The education and careers section which has had a corner of its own in the exhibition for some years will, once again, be arranged and should prove of interest to visitors concerned with studies and research.

Among A.E.I. products to be found on stand F9 will be those of the Cable Division: supertension cables—solid, oil-filled, and gas-cushion types; cables for railway electrification, collieries, and ships, and l.v. cables of various types, including plastic mains, F.I.N.D., and Solidal. A section of the cross-Channel d.c. power cable, now being manufactured for laying later this year between England and France, will also be on show.

A selection from the range of A.E.I. wiring accessories will be displayed, including cooker control units, switches, sockets, and plugs—among them the Reguplug, subject of the article on page 65. Joint boxes, service fuses, cartridge fuse-links, connector and terminal boxes, glands, distribution panels and pillars will form part of the distribution equipment section.

The activities of the Construction (Cables and Lines) Division will be shown pictorially on this stand, illustrating many of the major contracts carried out by its engineers during the past year.

▲ A corner of the cable raceway under the control room, showing multicore p.v.c. cables and marshalling boxes.

Extensive cabling at BERKELEY

Control cable marshalling box and incoming multicore p.v.c. cables in the turbine hall cable raceway. ▼

RISING FROM BESIDE the Severn in western England are the two 180ft high reactors of Berkeley Nuclear Power Station, flanked by their associated boiler units. No. 1 reactor is nearly complete. It is now undergoing commissioning tests and, when the design has been proved, fuel loading will be started at the end of March. This No. 1 reactor should be ready for commissioning towards the end of the year after extensive mechanical, electrical, and physics tests. Reactor No. 2 is scheduled for commissioning in the summer of 1962. Civil and mechanical work at Berkeley is virtually completed and the emphasis is now on cabling and instrumentation.

Berkeley, situated by the River Severn estuary, between Gloucester and Bristol, is being built by the A.E.I.—John Thompson Nuclear Energy Company Limited for the Central Electricity Generating Board. Work began on the site at the beginning of 1957, by first of all diverting the course of the Conigre Pill, which ran through it, and raising the level by an average of 10ft. The finished site will cover sixty acres.

The two similar reactors are of the natural uranium carbon dioxide gas-cooled, graphite moderated type, serving sixteen boiler units (eight for each reactor) which drive dual-pressure turbo-alternators generating at 11·8kV, each of 83MW capacity. Their net output to the national grid will be 275MW. The reactors are built on concrete rafts 150ft in diameter and 14ft thick.

More than 190 miles of A.E.I. cables are being installed throughout Berkeley for power, control, and station services. The installation work is being carried out by the A.E.I. Construction Division and by N. G. Bailey, who are electrical sub-contractors to A.E.I.–John Thompson.

Sierack cable supporting system is being used extensively, more than 120 tons of this standard steelwork having been installed to date. Photographs on this page show a few of the multitude of cable runs which a project the size of Berkeley needs.

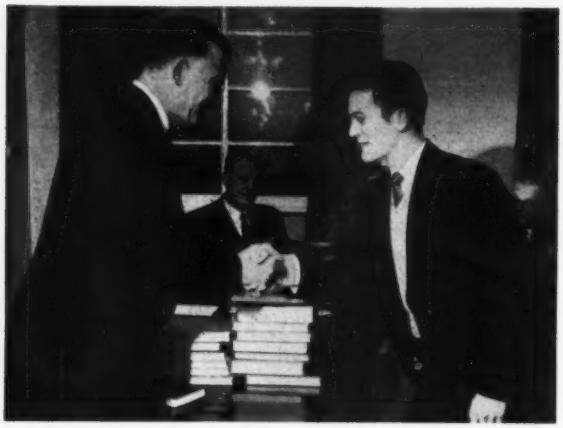
Live Lines—no Gloves

A LORRY-MOUNTED, insulated aerial boom carrying a fibreglass bucket is the hot idea used by American Electric Power System to enable their linesmen to work cool on overhead lines up to 380kV without gloves.

The fibreglass buckets are lined with metal mesh which is clamped by means of a cable connection to the live line being serviced. The men standing in the buckets are thus charged to the same voltage as the line—without ill effects, of course, as they are insulated from other contacts. On steel towers, insulating rods clamped to the towers hold conductors away from the structures while the men in the buckets work at repairs.

No gloves are necessary, interruptions for repairs are avoided, and time saved is of the order of 90%. American Electric reckon the method to be safer than conventional practice.

More Students Now — Comment at Gravesend prizegiving



Collecting their awards from Mr S. J. Wilson, divisional manufacturing manager, at the Gravesend gathering are (*top*) F. Leech, technician apprentice, and (*below*) D. Graham, commercial apprentice.

THE FIRST OF the new A.E.I. regional prizegivings to students successful in their 1960 examinations took place in the closing weeks of last year at the Gravesend Works of the Company. Students of Woolwich group were presented with their prizes for examination successes by Mr S. J. Wilson, manufacturing manager of the Cable Division.

Present at the prizegiving were the principal of Gravesend Technical College, Mr Fox, and the headmaster of Gravesend Technical School, Mr Stockdale—two gentlemen who had earned the thanks of those responsible for the Education and Training Scheme by their constant help and co-operation.

They heard Mr G. O. Allerston, deputy education manager for the group, state that today the group looked after about 1 000 students under the scheme, compared with 250 under the previous Henley arrangement.

Mr S. J. Wilson, who was in the chair, pointed out that although the prizegiving occasion which the students were attending was less elaborate than the "conversaziones" to which they had been accustomed in the past, this in no way indicated a lessening of the management's interest in the students themselves. That day's function would probably set the standard for future occasions.

He presented prizes to seventy-five students ranging from craft apprentices to commercial apprentices who had been successful in various stages of their studies. The prizewinners included several staff who had earned rewards for studies undertaken on their own initiative in their spare time.

A speech of thanks to the Company was made by F. Leech. Mr Leech had been awarded a technical State scholarship but he had chosen to continue his training as a student apprentice and to follow a sandwich course of study at the Woolwich Polytechnic, leading to the award of a diploma in technology.

. . . but no prize for this one!

URGENT ASSIGNMENT. Send a photographer 120 miles north, fully equipped to get a pictorial record of an important cable contract, and what happens?

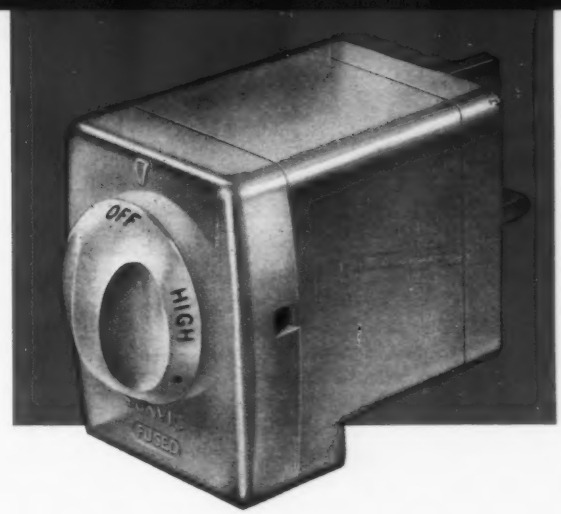
The weather in the south has been cold but fine for a few days. As he travels, our man on the job sees the skies darken and as he arrives, now contemplating the weather anxiously, the clouds release a blizzard of stinging snow!

Philosophically, he does what he can. And what emerges from the darkroom? Well—judge for yourself!

(The photograph *should* show a trifurcating box, used to separate the three cores of an oil-filled cable, mounted on a steel tower.)

The REGUPLUG

Heat Control in a Plug



THE REGUPLUG is, briefly, a 3-pin plug with a built-in Sunvic Type TYX Simmerstat. It is used in place of an ordinary 3-pin plug fitted to the flexible lead of an appliance and is a device for varying the energy input to any electrical heating apparatus.

The Reguplug is a means of direct control. It is not a thermostat—that is to say, it does not operate in relation to the surrounding temperature at the point of installation. The Reguplug is designed to give infinitely variable control between the "off" and "full" settings and the appliance stays at the resulting controlled temperature until the control is altered. Between these settings the control is fully variable: an electric sterilizer to which a Reguplug is fitted can, after boiling-point has been reached quickly with the control knob set to "full", be set to correct heat without boiling away furiously by direct adjustment of the control knob. Thus, besides the advantage of direct heat control, the Reguplug results in saving of electricity.

A particular setting of the Reguplug will always give the same result, so that having determined the setting for a particular application, on future occasions, for the same application, the Reguplug can be switched to that setting immediately the required temperature is reached.

Operation

The Simmerstat regulator incorporated in the Reguplug operates by opening and closing a snap-action switch of the micro-gap type in the load circuit at short, definite time intervals. The percentage of time "on" to the total time determines the level of the power input.

The essential part of the Simmerstat mechanism is a strip of bimetal. This bimetal carries a small heater wound on to a mica former, the heater windings being connected in parallel with the load. When the current is switched on, the windings heat up and the bimetal deflects until it opens the switch. The circuit remains open until the bimetal cools sufficiently for the switch to close again. The cycle is then repeated.

The deflection of the bimetal strip is governed by the exterior control knob, which is connected to a cam. As the knob setting is increased, the cam increases the distance that the bimetal must deflect before it opens the switch. Thus the "on" time is increased and the "off" time decreased, giving a progressive increase of percentage input for the regulator used in the Reguplug.

13A and 15A Types

The Reguplug is available for 13A ring circuits (flat pin) or 15A circuits (round pin), complying as far as possible with B.S. 1363 and B.S. 546 respectively. The 13A type is, of course, fused, and the cartridge fuse is so placed as to be changeable in a matter of seconds without dismantling the plug. Both types are designed for 230/240V mains, but they can be used on 200/250V supplies.

A cord grip for the 3-core flexible connection is included in the plug body and the terminals themselves are marked uncompromisingly RED, BLACK, and GREEN in addition to the corresponding letters L, N, and E.

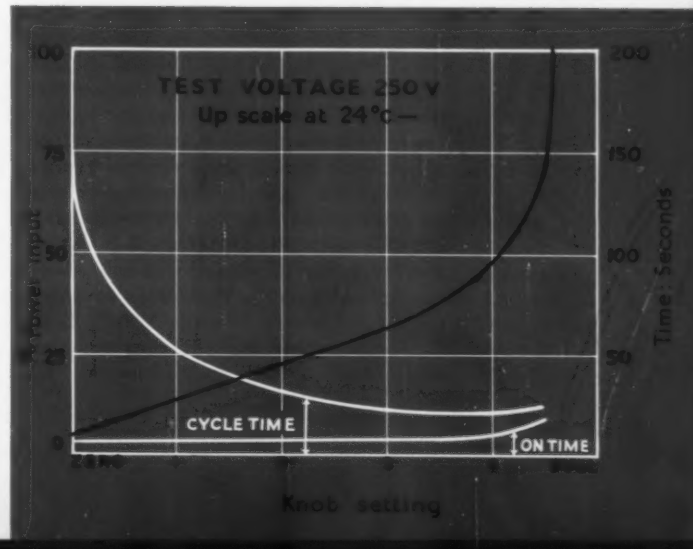
The Simmerstat control contained in the Reguplug has fine silver contacts to ensure top electrical performance and is fitted into a stout, high-quality white or brown moulding. The control knob has definite dwells in the "off" and "full" positions for exact setting at these positions.

Both types of Reguplug are $2\frac{1}{2}$in. wide by $2\frac{1}{16}$in. deep. The 13A version projects $3\frac{1}{8}$in. from the socket when plugged in, and the 15A version projects $2\frac{3}{8}$in.

Home retail prices are: 13A flat pin (fused) type 37s. 6d.
15A round pin type 35s. 0d.

The Reguplug has any number of uses in the home, in hospitals, at catering establishments, and in industry. It has a use wherever apparatus or utensils are not required at full heat all the time.

This useful accessory is now being marketed by the A.E.I. Cable Division through the Distribution Equipment Sales Department at 145 Charing Cross Road, London, W.C.2.



Wood Piddock with a taste for lead

MENTIONED IN *Science* from investigations by the Marine Laboratory of the Florida State Board of Conservation for the Florida Power Corporation is evidence of a hazard to submarine cables by the Wood Piddock, *Martesia striata* Linnaeus.

Three such attacks have been recorded in Florida waters and seem to have occurred under turbid conditions at varying degrees of salinity. Two verified attacks were in Boca Ciega Bay, St Petersburg (1959), and Ortega River, Jacksonville (1956). The third, probably attributable to this species, occurred at Lake Worth, West Palm Beach, in 1945. All three attacks were on the lead sheath of power cables after the steel armouring wires had rusted through (presumably following damage to the overall jute serving), exposing the sheath.

The Boca Ciega Bay cable, the latest attacked, had asphalt-impregnated jute serving beneath the armouring wires and it is not known whether this jute layer was penetrated before the lead. Although the lead was exposed, as mentioned, there was no evidence of abrasion or oxidation on the lead surface. The exposed lead "was both pocked and riddled with small holes in each of which could be seen a small molluscan shell . . . the molluscs proved to be young pholadids Martesia striatus Linnaeus".

In the section of attacked lead available for examination the greatest hole was about 6mm diameter at a depth of about 2mm in the lead. Five of the ten borings in the section (125mm long) had completely penetrated the lead sheath, which was 3mm thick. This particular attack took place at a depth of only 8ft.

Boring into such hard material by these molluscs is unusual, and the specimens from the lead sheaths are considered abnormal.

New British Standard

B.S. 1442:1960—Galvanized Mild Steel Wire for Armouring Cables

This Standard has been revised and now applies only to galvanized mild steel wire (sizes 0·160in. to 0·018in.) for the armouring of *land* cables for electrical purposes.

With the increasing use of non-metallic sheathed cables in which the wire armour serves as the sole earth continuity conductor for certain purposes and types of cables, the resistance of the armour becomes important. Therefore, in the revised edition, there is a clause stating that for certain purposes and by agreement between purchaser and manufacturer, the d.c. resistance of the galvanized wire shall be measured. Maximum resistance figures are given for each of the sizes of wire and for convenience are expressed in ohms per 1 000yd of wire at 20°C (68°F). *Price* 4*s.* 0*d.*

Copies of this Standard may be obtained from the B.S.I., Sales Branch, 2 Park Street, London, W.1.

Book Reviews

The Practical Electrician's Pocket Book
Edited by **Roy Norris**

Electrical Radio and Trading

530 *pp.* *Price* 7*s.* 6*d.*

Kept up to date by yearly revision, the 1961 edition of the *Practical Electrician's Pocket Book* marks the sixty-third year of its appearance.

New chapters in this useful publication are on Automation, Automatic Oil-burning Units, Maintenance of Motors, Wireman's Tools and Accessories, Staff Location Systems, and Transformers. Other sections have been revised or replanned to increase the scope of the book, the section on Repairing Domestic Appliances, in particular, having been considerably enlarged. Its thirty-four chapters treating of practical aspects of the electrician's many tasks keep this book among the annual "musts".

The Relay Protection of High-voltage Networks
By **G. I. Atabekov**

Pergamon Press

574 *pp.* *Price* 84*s.* 0*d.*

Although not received for review, this book should, we think, be brought to the attention of readers.

It is a translation of a Russian monograph by an outstanding professional engineer who has gained a Stalin Prize for his work in the high-voltage field.

Professor Atabekov combines the technique of relay protection and short-circuit calculation theory in his treatment and contributes to the literature on the subject his development of the method of circle diagrams. Contents include investigation of sequence networks, use of vector loci, calculation of transients, symmetrical component filters, power directional devices, distance and carrier protection, and differential current protection.

Book Briefs

Low Frequency Amplifier Systems *By* **Alexander Schure**

Chapman and Hall

70 *pp.* *Price* 32*s.* 0*d.*

One of an "Electronic Technology" series from America, this is a single volume in two sections. It deals with amplifiers designed for low-frequency spectrum work in the range from zero to 100 000 cycles.

Advanced Magnetism and Electromagnetism
By **Alexander Schure**

Chapman and Hall

96 *pp.* *Price* 37*s.* 6*d.*

One of the same series as the previous volume. A clear, explanatory treatment of first principles for students—who may, however, find that the price places it out of reach.

What does the U.K. want in tower design?

(CONTRIBUTED)

THE HEADING TO this page is prompted by an item in *Design*, the monthly journal produced by the Design Centre, London. It is quoted, with permission, in full:

END OF THE LINE?

The South of Scotland Electricity Board recently introduced a new pylon constructed in tubular steel, to the design of Tubewrights Ltd, a subsidiary of Stewarts and Lloyds Ltd. It is claimed that the tubular steel pylon is lighter, more graceful and much less expensive to erect than a conventional angle iron tower.

The design is probably the ultimate refinement, structurally speaking, of the ordinary pylon. However, it still cannot be said either to be invisible or to blend into the landscape, although the supply authority evidently wishes it were, or would.

Perhaps the time has come to give up trying. No one nowadays expects roads, bridges and dams to be invisible. Such things can have a frankness and grace of their own which reveal man in the landscape not as a desecrator nor as an apologist, but as an evolutionary phenomenon who has a natural right to be there.

The pylon designed by J. Masson for Electricité de France (Design 114/55) shows what can happen when a designer stops wishing his product were invisible. His proportions and details are unashamedly chosen on the scale of the tower. However, even this solution is far from perfect. Transmission line design is a field which should be considered wide open for new thought.

L. BRUCE ARCHER

Food for thought here: but is the author of this piece really justified in his criticisms?

The tubular-steel tower is a creditable work of design—designed, as are the conventional towers constructed of angle sections, to do a functional job as economically as possible with available materials. Tower design takes into account not only the stresses and strains to which such structures are subject but also the specified electrical clearances and the use of standard components, such as insulators. Without doubt, designers of towers in this country consider the aesthetic appearance of their structures—the 275kV supergrid towers are graceful structures—do they lack, as L. Bruce Archer implies, proportion and details "unashamedly chosen on the scale of the tower"?

If the several organizations whose business is tower design have ever wished that their structures were invisible, the wish must have been made in silence. On all the evidence, they assume that a tower of this kind *is* a symbol of man as an "evolutionary phenomenon" (don't mistake those inverted commas—we have several evolutionary phenomena walking about the office right now, and they like their electricity ready to hand and as cheap as possible!).

But, on the other hand, a designer of bridges (for example), while designing primarily a bridge, does take into account its appearance relative to its location and purpose. Some things are designed to fit their surroundings. Others must be designed and fitted to their surroundings. It is evident that good design looks well whatever the surroundings, but few people ignore the surroundings, especially when the design, however good it is, must be a symbol of man etc. The supply authorities, given a series of functional structures which must support an overhead line, take the trouble to site them as advantageously as possible with regard to the surrounding amenities. Surely no apologetic is needed?

The French design is a beauty. It was tailored to Electricité de France requirements for 225kV working as a special study in aesthetic design. But what the designer M. Jean Masson did have in mind regarding its visibility was, to quote the official French write-up, that the tubular construction was "less visible" than steel angle! At the time (1957) of its début, also, its cost was higher than the cost of the conventional tower, and it was suggested that its use would be limited to special circumstances.

The French type of single-circuit design requires a wider wayleave strip per circuit than the double-circuit towers favoured in this country. This consideration weighs heavily when charges are at a premium, and wayleave consents so difficult to obtain—as they are here. Technically the single-circuit towers are preferable, but their use means two towers instead of one of the double-circuit type. There are other high-voltage tower designs aesthetically pleasing in which this, and other factors, must be considered for U.K. conditions. The "ordinary pylon" does not come off too badly after all.

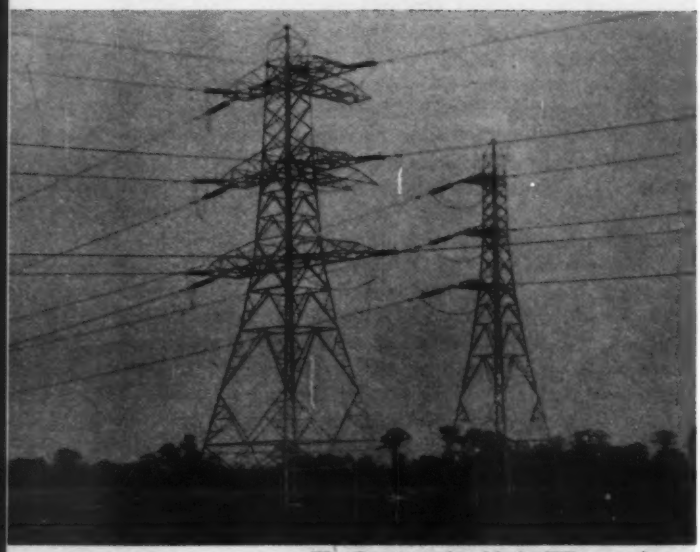
If power is to be transmitted over the minimum number of lines, the only solution is to boost the voltage—and retain the double-circuit formation. Amenity policy is behind the latest decision of the Central Electricity Generating Board to transmit at 400kV using towers 20ft higher than the present 275kV structures. The new lines will have a power-carrying capacity per double-circuit line of 3 000MW. Existing supergrid lines will be uprated where necessary using a different type of insulator, increasing their capacity from 1 200MW to 2 000MW.

In the light of these facts the two concluding sentences of L. Bruce Archer's article are intriguing. Perhaps someone will expound?

W. K.

1. Tubular 132kV tower by Tubewrights.
2. Tubular 225kV design by J. Masson.
3. Steel angle 132kV tower by Blaw Knox.
4. Steel angle 225kV tower by Blaw Knox.

▲ The line from West Thurrock by the Southend arterial road.



The Orsett tee-in with the Tilbury–Elstree line, stage 5. ▲

▲ The 132kV interconnectors at Tilbury—construction almost completed.

275kV wor
River Th

Tie-up with the Cross-Chan Po

IMPORTANT SUPERGRID INTERCONNECTION work in the Tilbury, West Thurrock, and Northfleet areas adjacent to the River Thames is now being completed by A.E.I. construction engineers, for the C.E.G.B. Eastern Division.

The various 275kV overhead lines forming the interconnections are shown on the sketch opposite, from which it can be seen that from West Thurrock construction work covers: a double-circuit line north-east to Orsett, where a special tower gives a tee-in to the existing Tilbury–Elstree 275kV line; a spur out of the substation for a future line to Barking; and another which bends south to meet the northern anchor tower of the high Thames crossing which is under construction (the actual crossing is not an A.E.I. contract) and continues from the anchor tower on the further side of the river to a new 275kV substation at Northfleet West.

Incidentally, Northfleet West will have a supergrid connection to Lydd, where the cross-Channel d.c. power cable terminates at a convertor station, so that these interconnections have been planned with the facility of the two-way power exchange between Britain and France in view. Power from Dungeness nuclear power station will also be transmitted over these lines.

The Tilbury–Elstree supergrid line shown on the map has been working at 132kV until recently, terminating at existing 132kV substations at each end. Part of the unified scheme covered by the contract included the transferring of these line entries from their 132kV sites to the newly erected 275kV substation at Tilbury and the Elstree substation extension. These new terminal arrangements bring in the circuits from the first double-circuit tower out from the substation to two separate ST (single-circuit) terminal towers—an arrangement which not only gives greater flexibility when considering the angle of the incoming line, but also allows termination of lines in bays not adjacent to each other in the substation compound. This arrangement is typical of all 275kV terminations on the present contract. The photograph on the cover shows the terminations at Tilbury.

At Tilbury, also, two new double-circuit 132kV 0·4sq.in. S.C.A. interconnectors have been erected, within the provisions of the contract, between the 132kV and the new 275kV substations. Thus sixteen terminal towers have been erected complete with downleads and terminations to substation equipment: twelve 275kV ST type towers and four 132kV DT type towers.

rk near the Thames

anel Power Link and Dungeness

The Thames crossing consists of four towers—two high suspension structures, each with an anchor tower—in a straight line. The West Thurrock–Northfleet West line, which includes the crossing, deviates at an angle from the anchor towers, and design considerations for the latter required two additional ST type towers to be installed, one near each anchor structure, to bring the west circuit on the north side of the Thames and the east circuit south of the Thames into line with the following deviated section on each side of the river.

It will be seen that the length of the new lines is not great—about 8½ miles of supergrid and half a mile of 132kV, all double-circuit lines. But the amount of work involved, much of it concerned with connecting to or modifying existing lines, is equivalent to straightforward work on a much longer line.

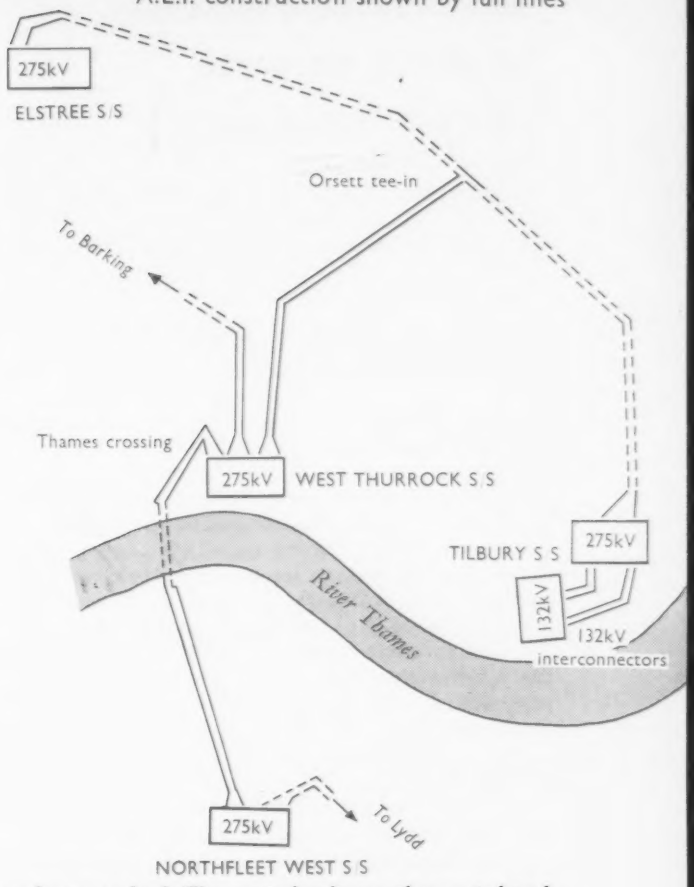
A surprising variety of subsoil conditions was encountered, from hard chalk to estuarine mud. On the mud, piling was resorted to—bored piles of up to 50ft long being used with mass-concrete foundations.

The longest length of new construction is from West Thurrock to Orsett, in which the only crossings of note are the Southend arterial road and the Tilbury–Southend railway which is shortly to be electrified.

The junction at Orsett with the Tilbury–Elstree line is made on a special junction tower of Blaw Knox design, type DJX, with three sets of crossarms. The work here was planned to avoid a stimultaneous outage on both circuits of the existing line. The diagram illustrates the sequence of construction. A temporary ST tower was erected as near as possible to the line and the east circuit was made dead, transferred to the temporary tower,

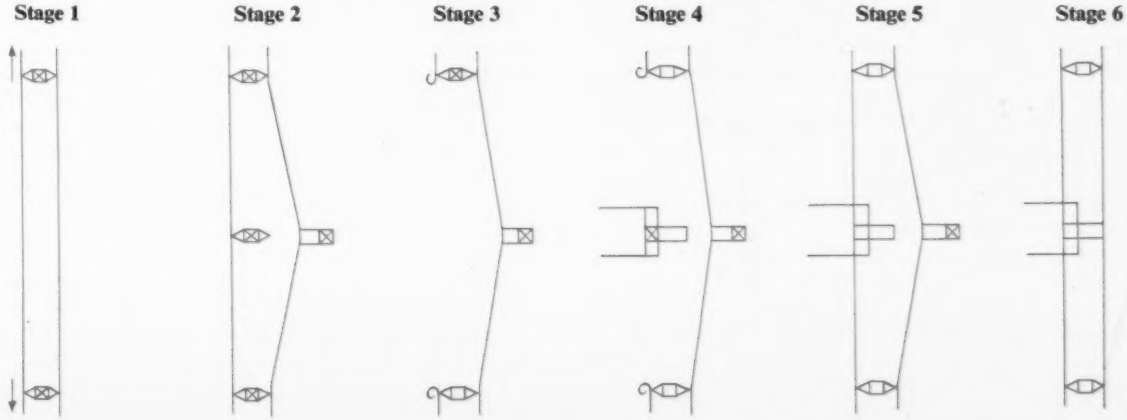
SKETCH OF SUPERGRID WORK

A.E.I. construction shown by full lines



and re-energized. The west circuit was then outed and dismantled, a redundant straight line tower which occupied a site near the determined position of the new DJX tower also being removed. The new circuits to West Thurrock and the west circuit of the Tilbury–Elstree line were then connected to the DJX and re-energized, forming the West Thurrock–Elstree and the West Thurrock–Tilbury circuits. The last stage, the transferring of the east circuit to the junction tower and the dismantling of the ST tower, will be carried out in the spring of this year, to comply with C.E.G.B. circuit-loading requirements.

▼ **Construction sequence at site of the Orsett tee-in mentioned in this article.**



Unarmoured Submarine Cable for Deep-sea Carrier Telephony

by A. L. MEYERS, B.Sc.(Eng.), M.I.E.E.

(Transmission Engineer, Submarine Cables Limited)*

Paper presented to the Ninth Annual Symposium on "Technical Progress in Communication Wires and Cables" at Asbury Park, New Jersey, 30 November 1960.

Abstract

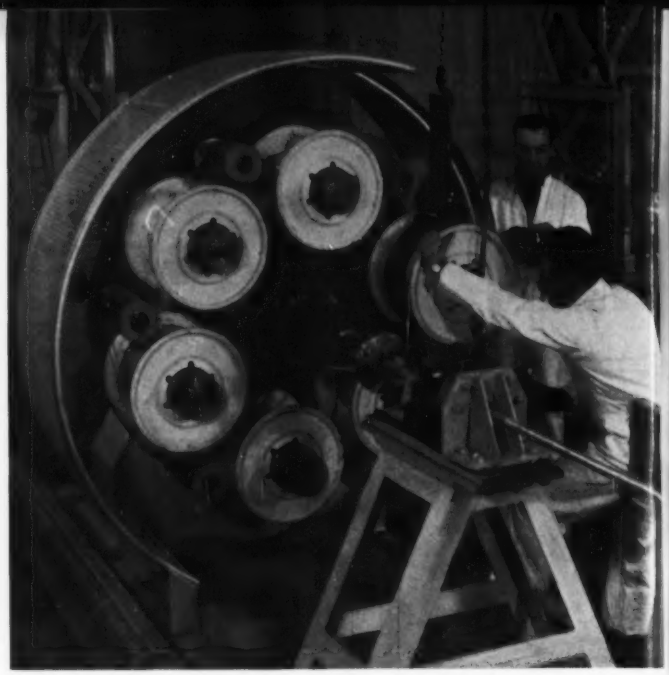
AN UNARMOURED TYPE of deep-sea coaxial cable, with the strength member inside the inner conductor and an external plastic sheath, was proposed in 1951 by the British Post Office to Submarine Cables Limited. It gives increased circuit capacity and permits the laying of repeaters in rigid housings for two-way operation. After development and trials, the new cable was chosen for the deep sections of the Canadian transatlantic telephone cable, due for completion in 1961 as the first link in a proposed Commonwealth system around the world. This paper describes the advantages, development, and manufacture of the cable, and reviews future possibilities.

Introduction

Soon after the completion in September 1956 of the first transatlantic telephone cable system (TAT-1, Ref. 1), it became apparent that the rapid increase in telephone traffic would necessitate the early provision of additional cables. Previously radio circuits had been used for transatlantic telephony, and the improvement in quality and reliability with cable circuits greatly encouraged public demand.

The main Atlantic crossing for TAT-1 was from Oban, Scotland, to Clarenville, Newfoundland, a distance of nearly 1 950 nautical miles (n.m.). Two coaxial cables with conventional external armour were used, each including fifty-one submerged repeaters spaced at approximately 37·5n.m. This gave thirty-six speech channels of 4kc/s width in a carrier frequency band from 20 to 164kc/s. The deep-sea type of cable is illustrated in Fig. 1; a 0·62in. coaxial, insulated with polyethylene compound, was armoured with twenty-four galvanized 0·086in. steel wires. More than 90% of the cable required was manufactured by Submarine Cables Limited in a factory specially constructed and equipped for the purpose on the River Thames at Erith, Kent. The flexible repeaters, designed by Bell Telephone Laboratories and manufactured by the Western Electric Company in a special factory at Hillside, N.J., were contained under a bulge in the armour, so as to be capable of being laid by the normal gear of a cableship. Owing to the severe limitation of space, only one-way amplification could be provided, which explains the necessity for two cables.

* *A Company jointly owned by Associated Electrical Industries Ltd and British Insulated Callender's Cables Ltd.*



Forming the co-axial outer conductor of six aluminium tapes over the extruded core of the lightweight cable discussed in this article.

For the comparatively shallow stretch of 270n.m. from Newfoundland to Nova Scotia, a single cable of similar design but heavier armour was provided with fourteen submerged two-way repeaters encased in rigid housings. Two more repeaters were inserted in the land cable across Newfoundland. The internal units of the repeaters were made by Standard Telephones and Cables Limited and the housings were supplied by Submarine Cables Limited. This section of TAT-1 was designed for sixty circuits in the frequency bands 20 to 260 and 312 to 552kc/s.

TAT-1 was the joint enterprise of the American Telephone and Telegraph Company, the Canadian Overseas Telecommunications Corporation (C.O.T.C.), and the British Post Office. Following its success, similar systems have been installed, in 1957 between San Francisco and Honolulu, and in 1959 a second transatlantic link (TAT-2), this time to Penmarch, France. Submarine Cables Limited produced 2 000n.m. of cable for the former and over 2 200n.m. for the latter, and their cableship *Ocean Layer* assisted the Post Office ship *Monarch* in the laying of both. The tragic news of the destruction of C.S. *Ocean Layer* by fire, fortunately without loss of life, came when she had nearly completed her share of the laying of one of the cables to France.

Meanwhile, as early as 1951 the Post Office had proposed to Submarine Cables Limited a novel type of deep-sea coaxial cable (Ref. 2), which has since been called the "lightweight" cable. This dispensed with external armour and incorporated a strength member inside the inner conductor. An experimental length was quickly produced and subjected to extensive mechanical and electrical tests, but further development was slowed by the heavy commitments of both parties for TAT-1. However, in 1956 C.S. *Ocean Layer* carried out sea trials (Ref. 3) with a

length of 5n.m. of 0·80in. cable containing a rigid telemetering repeater. The cable is shown in Fig. 2; it had an aluminium outer conductor and a polyethylene sheath. Improvements were effected, and 1958 saw a full-scale trial by H.M.T.S. *Monarch* with 55n.m. of 0·99in. cable and two rigid repeaters. New multiple-sheave gear, supplied by The Telegraph Construction and Maintenance Co. Ltd, Greenwich, was used for launching the repeaters without stopping the ship.

A similar type of unarmoured coaxial cable has been independently developed by the Bell Telephone Laboratories, trial lengths of which have been made at the works of the Simplex Wire and Cable Co. at Cambridge, Mass.

Canadian Transatlantic Telephone Cable

This project (Ref. 4), known as CANTAT, is due for completion in 1961, and is intended in part to meet the growing demands for transatlantic telephony. It consists of two parts, CANTAT "A" from Oban, Scotland, to Hampden, Newfoundland, nearly 2 000n.m. and CANTAT "B" from Corner Brook, Newfoundland, to Grosses Roches on the Canadian mainland, about 400n.m. CANTAT "A" will be owned jointly by Cable and Wireless Limited and the C.O.T.C. and CANTAT "B" solely by the latter. Submarine Cables Limited has been given the contract for all the submarine cable for CANTAT "A". For CANTAT "B", they have been entrusted not only with the manufacture and laying of the cable and submerged repeaters, but also with special terminal and power feed equipment which will be made by Associated Electrical Industries Limited. The Greenwich factory of Submarine Cables Limited has been re-equipped to make the cables.

For the deep sections of the main crossing, lightweight cable has been chosen, while the shallower sections, down to about 500 fathoms, will be armoured. Approximately eighty-five rigid two-way submerged repeaters will provide eighty circuits of 3kc/s width in the bands 60 to 300kc/s and 360 to 608kc/s. There will be a further four repeaters in the land cable across Newfoundland. The 3kc/s channels have been developed by the Post Office (Refs. 5, 6) to give a quality only slightly inferior to that of standard 4kc/s channels; their expense is justified for costly long-distance submarine cable links.

The greatest depth on the route of CANTAT "B" is only 250 fathoms, so heavily armoured 0·935in. coaxial will be used throughout. This coaxial has an inner conductor of solid copper 0·260in. in diameter. The link will include twenty two-way repeaters to give 120 circuits of 4kc/s width in the ranges 60 to 552 and 672 to 1 164kc/s.

Lightweight Cable

An external protection of steel wires is unnecessary for submarine cable laid in oceanic depths, which constitute a quiescent environment. The reason for applying such armour to deep-sea cables has been to provide strength for laying and recovering the cable, rather than for protection. It is accompanied by a serious disadvantage in that the cable untwists freely under tension, thereby by tending to throw loops on the seabed as the ship rises and falls in an ocean swell (Ref. 7). Under subsequent tension the loops may be drawn into kinks, which may seriously damage or even break the cable. This trouble is aggravated by the heavy weight of large coaxial cables, and by rigid repeaters inserted in them. A cure would be to apply two layers of armour wires in opposite directions to make the cable non-twisting, but this would entail increased cost, stronger cableship gear, and reduced storage capacity in the ship's tanks.

Owing to skin conduction at high carrier frequencies, only a small thickness of the inner conductor is effective for transmission. Consequently the strength member of a coaxial cable can be placed inside the inner conductor. In this position high tensile steel wires can be arranged in layers in opposite directions so as to be torsionally balanced, that is to have no tendency to untwist when subjected to tension, thus avoiding this objectionable feature of externally armoured cable. Moreover, the steel is completely protected from the corrosion in sea water that may affect the strength of conventional cable. Adequate strength can be obtained with a central steel strand about 0·3in. in diameter.

With an overall diameter and cost similar to that of armoured cable, a larger coaxial can be used with increased transmission capacity. An even greater economic advantage is that rigid repeaters can be used, with space for directional filters to permit two-way working over a single cable.

It is to be noted that the remarks above apply only to deep-sea high-frequency cable. In depths less than about 400 fathoms, submarine cables may be affected by abrasion against rocks and are liable to damage from trawls and anchors, and serious consideration is advisable before dispensing with external armour. Even in deep water a coral bottom may be unsuitable for unarmoured cable, owing to possible damage by dragging during laying or recovery. Again, it has been proposed to use unarmoured telegraph cables in deep water (Ref. 8); here, however, all the cross-section of the conductor is effective in transmission, and an adequate combination of conductance and strength can only be obtained by an increase of core size which somewhat offsets the economic advantage.

For the shallower depths it is advisable to use armoured cable. External armour over a jute bedding can be applied to lightweight cable, but this is rather an expensive construction. Where long shallow sections occur at the ends of a deep-sea route, economy can be effected by using a smaller "simulator" cable, so called because it imitates the impedance and attenuation/frequency characteristic of lightweight cable. Consequently the same design of repeater can be used throughout, although at a closer spacing in the shallower sections. Simulator cable has a central strand of mild steel wires surrounded by a copper tape of the same thickness as in the lightweight cable and insulated to the same diameter ratio. The outer conductor is formed of copper tapes instead of aluminium, because electrolytic action between

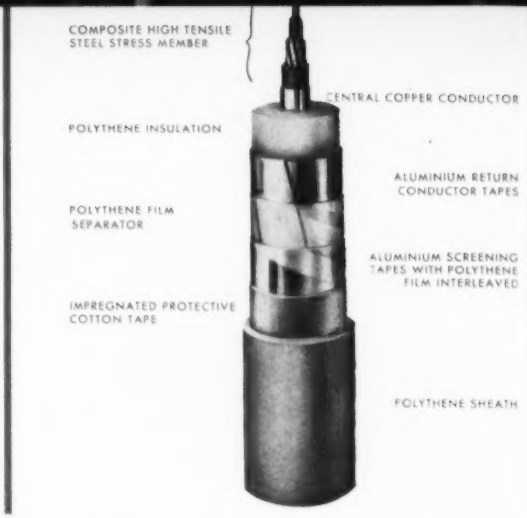


Fig. 1. (*left*) **Deep-sea armoured cable used for TAT-1.**
Fig. 2. (*centre*) **Early type of 0·80in. lightweight cable.**
Fig. 3. (*right*) **Present type of 0·99in. lightweight cable.**

uninsulated aluminium and the steel armour wires would cause rapid corrosion.

A comparison of lightweight cable with deep-sea armoured cable as used for TAT-1 is given in Table 1. Details for the 0·80in. cable are for the design shown in Fig. 2, and some revision would be required to include developments which have been effected for the 0·99in. cable. The modulus, defined as the length in water that the cable strength can support, is somewhat misleading for lightweight cable; it is not claimed that lightweight is superior to armoured cable in accordance with the figures in that column. At high frequencies the attenuation is approximately proportional to the square root of frequency.

Table 1 Comparison of Light and Armoured Cable

Cable	*Diameter*		*Weight*		*Strength*	*Modulus*	*Attenuation at 608kc/s*
	Core	*Overall*	*Air*	*Water*			
	in.	*in.*	**tons/n.m.*	**tons/n.m.*	**tons*	*n.m.*	*dB/n.m.*
Lightweight	0·80	1·02	1·5	0·5	5·1	10	2·73
Lightweight	0·99	1·30	2·2	0·6	7·5	12·5	2·11
Armoured	0·62	1·27	3·1	1·8	12·5	7	3·21

* Long tons of 2 240lb.

The advantages of lightweight cable have not been achieved without the introduction of additional problems. Since the tensile member is at the centre, whilst tensile loads are applied to the outside, friction between successive layers of the cable must be adequate to transfer the tension. Also every joint in the inner conductor assembly is a splice in the tensile member, and to keep these to a minimum it is most desirable to make the cable in long lengths. Aluminium was chosen for the outer conductor to reduce the weight, in spite of its susceptibility to corrosion under certain conditions and its contributing an extra 6% to the attenuation. Corrosion can only occur in the event of a gash or break in the sheath, and long-term tests in the laboratory and in the sea have indicated that the use of a corrosion inhibitor will be effective.

The use of two-way repeaters for a larger number of channels entails higher operating frequencies and closer repeater spacing (26·3n.m. for 0·99in. lightweight and 18·0n.m. for 0·62in. simulator cable), which aggravate the problem of equalization. It is proposed to insert an equalizer after every twelfth repeater to correct for any accumulated error between the gain of the repeaters and the loss of the cable.

Lightweight Cable Construction

A telescoped view of the present design is given in Fig. 3.

Tensile Member and Inner Conductor

In the early stages of development of the cable, a strand (Ref. 9) was designed using two sizes of steel wire, which gave satisfactory results as regards torsional balance. To improve the filling factor, the present construction has a die-drawn heart produced by British Ropes Limited, and around this a layer of high tensile wires is applied in the opposite direction.

The inner conductor is formed from an annealed copper tape 0·010in. thick, which is folded longitudinally round the tensile member and tightly closed by a box seam. The latter forms a small protuberance above a diameter of 0·322in., which slightly increases the capacitance of the cable. Development is in progress for the replacement of this conductor by a copper tape welded edge to edge by an argon-shielded arc in a continuous process, the tube so formed being subsequently drawn down on to the steel strand.

Insulation

The insulation is polyethylene of melt index 0·3, extruded tightly on to the inner conductor, the core diameter being electronically controlled to 0·990in. Early development was concerned with a core diameter of 0·80in. and a correspondingly reduced inner conductor assembly. The present larger size gives better transmission capacity and increased strength, adequate for the greatest depth, 3 500 fathoms, found on normal cable routes. It is only possible to obtain adequate strength with smaller core diameters by departing from the optimum

diameter ratio to such an extent that attenuation is seriously increased.

Outer Conductor Assembly

The outer conductor is a layer of six annealed aluminium tapes 0·018in. thick, applied helically. This operation is shown in the heading illustration on page 70. In early trials the tapes were held in position by a cotton tape impregnated with barium chromate as a corrosion inhibitor. It was found, however, that with this simple construction, crosstalk between layers of cable coiled in tanks prevented the accurate measurement of attenuation. Consequently an overlapped aluminium screening tape 0·004in. thick was added. In order to avoid instability due to random contacts between the layers of aluminium tape, they are separated by a polyethylene tape, and another polyethylene tape is interleaved with the screening tape. The polyethylene tapes are 0·005in. thick, and are specially produced without longitudinal orientation, to increase their resistance to tearing. The impregnated cotton tape is applied over the outer conductor assembly.

Experiments are in hand to find whether an outer conductor formed from a single wide tape, folded longitudinally round the core with a plain overlap, will give a sufficiently good performance in bending. If this is successful, the crosstalk difficulty should be eased, and there would be a welcome return to simplicity.

Overall Sheath

At present the outer sheath is polyethylene of melt index 0·3, tightly extruded (Fig. 4) in a layer 0·10in. thick to a diameter of 1·30in. There has been considerable investigation of other materials, such as high density polyethylene and polypropylene, but the most suitable seems to be a recently introduced copolymer of ethylene and butylene. It is likely that this will be used in the future.

Joints

The high tensile steel strand is jointed by coating the two ends with silicon carbide stuck on with shellac varnish, and inserting them in a steel sleeve which is then squeezed on to the strand in a 200-ton hydraulic press. A sleeve with a finished diameter of 0·59in. and a length of 5·5in. is sufficient to give a friction grip nearly equal to the strength of the strand. A copper wire let into a groove in the sleeve is soldered to the copper conductor on each side of the joint.

The polyethylene insulation is jointed by injection moulding. During replacement, the aluminium tapes are jointed by cold pressure welding. The outer polyethylene sheath is made good either by injection moulding or by a miniature extrusion process.

Repeater Terminations

At a repeater, the longitudinal tension during laying and recovery has to be transferred from the central steel strand to the repeater casing, and back again to the central strand. This is accomplished by armouring the lightweight cable for a short distance on each side of the repeater. The armour wires are applied directly over the sheath of the cable, and are secured in the conical armour clamps of the repeater. Only a few fathoms of armour are needed to effect the transfer of tension, but in practice the cable is armoured for twelve fathoms on each side of the repeater to facilitate passage through the special laying gear.

Inside the casing the lightweight cable is jointed to the smaller core which passes through the watertight glands of the repeater. Care is taken to keep the outer aluminium tapes insulated to prevent electrolytic corrosion.

Laying of Cable and Repeaters

Lightweight cable can be laid and picked up by the normal drums of a cableship, but provision has to be made for laying the rigid repeaters. The British Post Office has devised a multiple-sheave laying gear which is shown diagrammatically in Fig. 5. A steel bypass rope is attached by stockings to the cable across the repeater; the rope is slightly longer than the cable it bridges, so that

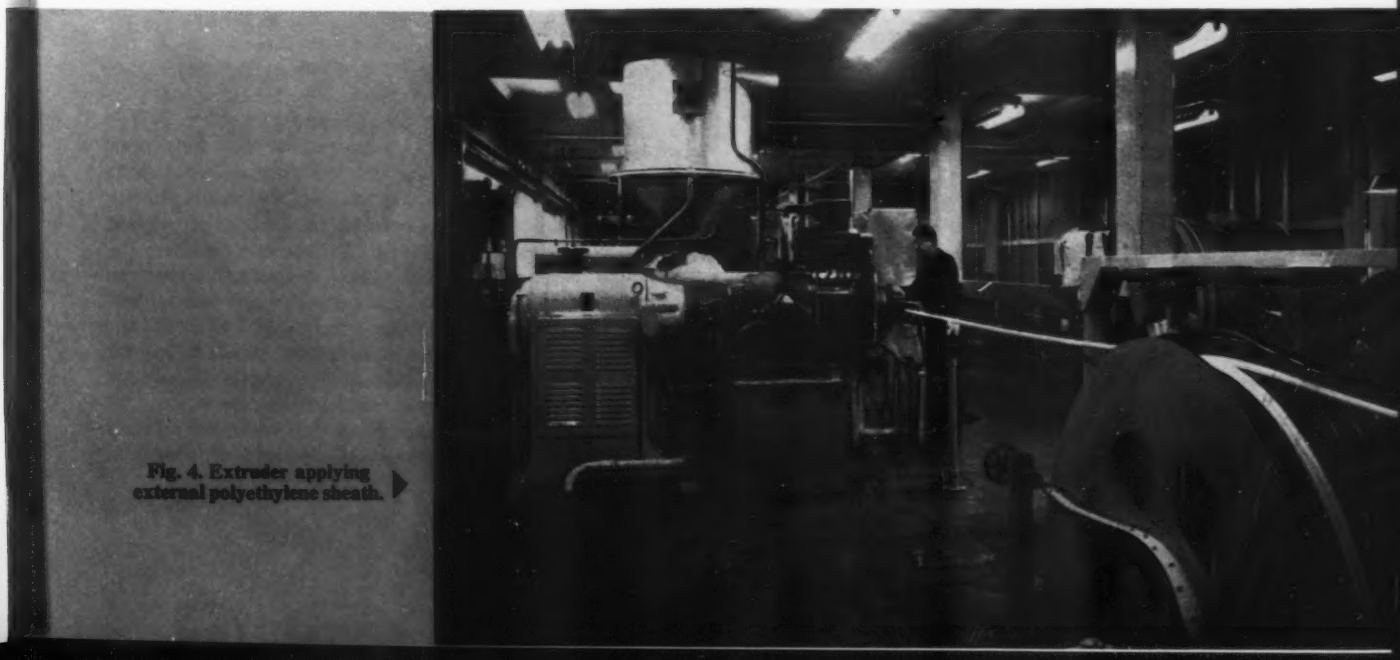


Fig. 4. Extruder applying external polyethylene sheath.

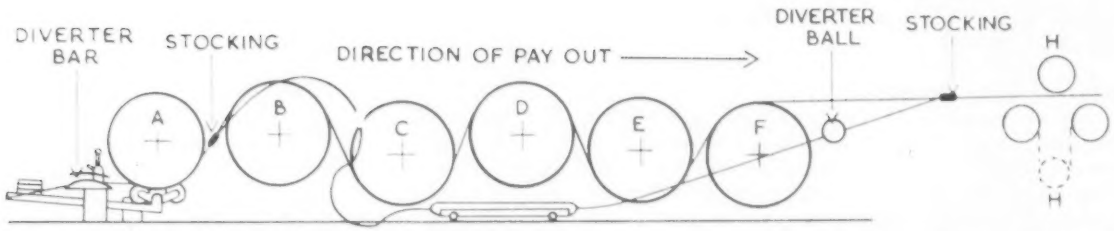


Fig. 5. Diagram of multiple-sheave laying gear. *(reproduced by permission of H.M. Postmaster General)*

after leaving the gear, tension is carried through the armoured tails and repeater. When the bypass rope enters the gear, the cable is diverted by an attached ball at a stool, and the repeater travels beside the gear in a trough. In the diagram, sheaves C, D, and E provide the braking, B and F increase the angle of lap on the braking sheaves, F also acts as a dynamometer, and A provides the necessary back tension. To maintain tension in the bypass rope as the trailing stocking nears sheave F, the rope is effectively shortened for a few seconds by a tuck put in it by a pulley H on a hydraulic plunger. Cable and repeater leave the ship over the stern sheave; this is guarded by large conical plates called "whiskers", over which the repeater slides. Although the ship does not have to stop when launching a repeater, it has to slow down to a speed of under two knots.

During laying, transmission measurements are made through the cable already laid, to provide more accurate data for the adjustment of cable length and equalizers than is obtained by correction of factory tests of attenuation to the estimated sea-bottom temperature and pressure. In armoured cable additional allowance has to be made for small changes of attenuation (Ref. 1) that occur immediately on laying and during subsequent ageing. Measurements on trial lightweight cable, particularly a length of 12n.m. laid early in 1959 and left on the seabed, indicate that laying and ageing effects are much smaller in lightweight than in armoured cable.

Future Possibilities

CANTAT will constitute the first link of the proposed Commonwealth submarine telephone cable system around the world (Ref. 10). The next will be the 8 000n.m. route across the Pacific Ocean from Vancouver to New Zealand and Australia (Ref. 11), via Honolulu, Fanning Island, and Fiji, due for completion by 1964. At the same time, the American armourless cable will doubtless be installed on oceanic routes. When these projects have been proved, it is to be expected that the armoured type of deep-sea telephone cable will become obsolescent.

Although repeatered transoceanic cables are costly, they are certainly a commercial proposition on routes with a high potential demand for telephone traffic. In this connection it should be remembered that when circuits of good reliability and quality are made readily available, the estimated growth of traffic is in practice often greatly exceeded.

There are two limitations to an increase in the number of circuits obtainable on long routes with submarine cable of a given size and repeaters with valve amplifiers. These are the performance of the long-life valves themselves, and the voltage permissible for power feed, which is mainly a question of the capacitors in the power separating filters of the repeaters. A total bandwidth of about 2Mc/s may become feasible, but it seems that further increase may have to await the development of transistor amplifiers of adequate reliability and bandwidth. With a band of 1Mc/s in each direction, corresponding to a repeater spacing of 12n.m. in 0·99in. lightweight cable, it may ultimately be possible to transmit live television programmes (Ref. 12), by compression of the frequency band required.

With larger numbers of repeaters in tandem, the reliability of the components in them would become even more important than at present. Repeater spacing could be increased by using a larger cable, but this would seriously decrease storage capacity in the cableships. At the higher frequencies, equalization would be more troublesome, and even the small dissipation factor of polyethylene, which is difficult to measure and control, would become important; but this might be overcome by improvements in equalization technique. For television, a reduction of delay distortion to tolerable limits would be necessary, and might be partly obtained by using the central part of the frequency band, where the distortion from filters is least severe.

The high cost of transoceanic cables justifies the development of expensive means of obtaining more circuits. One has already been mentioned: the introduction of efficient 3kc/s channels (Ref. 6) on the submarine sections. Another is T.A.S.I. (Time Assignment Speech Interpolation, Ref. 13), developed by Bell Telephone Laboratories. This equipment uses electronic switching so that a channel is occupied only when speech is present, and it enables thirty-six or more channels to carry twice the number of conversations. Much work has been devoted to the compression of the channel width required to transmit speech, and systems such as Vocoder and Vobanc (Ref. 5) have been developed; but so far the objective of a quality suitable for the public telephone network has not been achieved. Pulse code modulation also appears to offer little promise in this respect.

Finally, reference may be permitted to the recently publicized possibility of transoceanic communication by

means of passive reflectors placed in orbit by artificial satellites (Ref. 14). It is not intended to detract from the technical achievement of putting a metallized plastic balloon 100ft in diameter in orbit 1 000 miles above the earth; but some disadvantages of reflected radio circuits compared with submarine cable circuits should be pointed out.

1. Considerable development of ground-based equipment appears necessary to make use of the enormous potential bandwidth.
2. The high-power transmitters might become a troublesome source of interference to other communication systems.
3. It is estimated that twenty-four balloons in random orbits at 3 000 miles altitude would be needed to provide transatlantic coverage with an average interruption of 1 % of the time when no satellite was visible at adequate elevation from both terminals.
4. The reflector system would not give secrecy.
5. Piracy could not be prevented.
6. The system would be liable to deliberate jamming.
7. The balloons may be vulnerable to micrometeorites.
8. It is doubtful if speech quality would be as good as with cable.

Acknowledgements

Acknowledgement is made to the management of Submarine Cables Limited for permission to present this paper, to the British Post Office for information contained therein, and to the Symposium Committee for their acceptance of the paper at long range without formalities.

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Overseas readers' donation welcomed by the Electrical Industries Benevolent Association

SOME TIME AGO, when our predecessor journal *Distribution of Electricity* published its last issue, its subscription department was left with several small sums of money owed to readers abroad, who had paid their subscriptions in advance of the journal's date of demise. Currency regulations to some of these countries made it difficult to return these small sums, and we asked the readers concerned if they would agree to the money being donated to the Electrical Industries Benevolent Association for charitable purposes.

As a result of readers' support of this suggestion the E.I.B.A. was sent a Christmas cheque for £4 11s. 0d. which has been gratefully acknowledged by the Association. The following extract from a letter received is a tribute to the readers concerned.

The secretary of the E.I.B.A., H. Senior Fothergill, A.S.A.A., A.I.M.T.A., writes:

> This unexpected help from various parts of the world is a great encouragement to us, and we would like to thank all those kind people overseas who were willing that the outstanding amounts of their subscriptions to *Distribution of Electricity* should be given to the E.I.B.A. We sincerely appreciate the resulting gift, and the generous thought which prompted it.

PROBLEM CIRCLE

ON THIS PAGE we present a new series of problems for readers of ELECTRICAL DISTRIBUTION. This was a familiar feature to readers of *Distribution of Electricity* and we hope its return will be welcome.

How many Problem Circle friends remain with us after a lapse of six months? How many of our new readers are interested in brain-teasers? For our part we hope that interest in this once-popular feature has not faded and that the rest from brain fag (now at an end, you Problem Circle fanatics!) will bring forward a new crop of problems from the "members" of the circle. Let us hasten to add, to the uninitiated, that the only entry fee for "membership" is an attempt at solving the problems presented by the Editor and his willing allies who enjoy puzzling their fellows—the willing allies often getting the better of the Ed!

During the past decade or so, our problems have been almost solely mathematical but, if the problems deserve it on merit, there is no reason why, in future, we should not include brain-teasers of the cryptogrammatic kind and others which require more "puzzle sense" than mathematical knowledge.

As in all competitions, we must have a closing date. Readers can be assured that the postal services rarely let them down if they allow the normal mailing time in relation to the closing date given. Overseas readers are given a *mailing* date, and air-mail letter forms are the best medium for them to use to ensure early arrival. Perhaps it would be as well to reiterate the brief rules:

1. Envelopes must be marked "Problem Circle".
2. Solutions to problems must arrive before or on the date given as the closing date.
3. Solutions are kept unopened until the closing date and the prizes are awarded for the first correct solutions opened: this procedure gives any correct solution the chance of a prize.
4. Prizes: £1 10s. 0d. for each problem will be awarded to Problem Circle winners at home and overseas whose names are announced on this page.
5. No correspondence can be entered into.
6. The Editor's decision is final.

Right. Now to start the ball rolling with this month's problems.

January Problems

Neither of the problems is in the difficult category. In fact, the second one is in quite familiar form.

Problem No. 1

Two men who were skilled layers of a flooring material set to work one day to lay the material in a room 10ft square. As they stood in the doorway looking at the bare room, Jim said to his mate: "Hey, Joe, here's a puzzle. Those chaps at head office have calculated by area and they've sent us a roll 12ft 6in. long by 8ft wide from the warehouse. Beats me how we're going to lay it." And he stared morosely at the room.

But Joe was a bright young fellow and started drawing on the floor-boards to try to solve the problem. After a while he called Jim over to look at his sketch. "Well, I'll be blowed," said Jim, "we couldn't do it neater than that."

Joe had solved the problem using the minimum number of pieces. How did they cut the roll of flooring material?

Problem No. 2

The milkmaid has a full container which holds 16 measures of milk, and two empty jugs, one of which has a capacity of 9 measures the other having a capacity of 7 measures. But her two customers want 8 measures each put into their pails and the pails cannot be used for measuring, as they are different shapes and, besides, they are not graduated—nor are any of the other containers. Can you tell the mystified milkmaid how she can satisfy her customers in the quickest way?

Solutions to Problem Circle

Solutions to the Problems 1 and 2 should be sent to the Editor, ELECTRICAL DISTRIBUTION, 155 Charing Cross Road, London, W.C.2. Envelopes should be marked "Problem Circle". *Closing Dates:* 24 February 1961 for competitors resident in Great Britain, Northern Ireland, and Eire. For overseas competitors the *mailing date* specified is 24 March.

Before wishing all intending entrants "good luck" as they get down to solving these problems, the Editor would like to mention that he has a number of 15s. 0d. postal orders up his sleeve with which to pay for problems submitted and used on this page. Several of our old Problem Corner stalwarts have doubtless one or two new twisters to try out on their fellows and any new reader who feels of like-mind is cordially invited to submit problems for scrutiny. It may be true that there are no new problems but there must be "stumpers" familiar to you but not to others of the Circle.

Send problems to the same address given for competition entries. Letters which submit problems for consideration will be answered, but competition solutions themselves cannot be acknowledged, in accordance with the rules.